## DISCUSSION BEFORE THE RADIO SECTION, 10TH FEBRUARY, 1954

**Dr. J. S. McPetrie:** The two papers have appeared at a most opportune time when active discussions are taking place on extended television services and v.h.f. high-quality transmissions, and the authors' results summarizing the extensive survey work on v.h.f. propagation carried out in both this country and the United States should prove extremely useful to those responsible for planning such services. Recent published work on propagation has tended to concentrate on centimetre waves and their propagation beyond the horizon. Important as this work has been, particularly for radar purposes, the present papers should redress the balance by bringing us up-to-date on the factors affecting v.h.f. propagation, particularly within optical range of the transmitting aerial.

I was pleased to see the authors using statistical methods for analysing their results. I had already decided some years ago that if I ever had to undertake further radio field surveys I should adopt such methods. In field surveys, particularly at very high frequencies, the number of factors affecting the results is so great that their interpretation is often extremely difficult and tedious. By proper use of statistical methods some of the less significant information can be discarded, so that at last the wood can be seen through the trees.

When Dr. Saxton and I worked on this problem some years ago, we came to the conclusion that, except under certain special circumstances, there was little difference in the propagation conditions of horizontally and vertically polarized radiation at very high frequencies, and I was pleased to see the authors confirm this result from their more recent work. Another feature we found was the increased attenuation over built-up areas. Could this be interpreted as being due to the extreme roughness of effective terrain in such areas?

I remember that snow-covered ground sometimes improved v.h.f. transmission along the ground. Have the authors any information on this point, and if they agree, could the decreased attenuation be due to the snow covering effectively smoothing the previously rough terrain?

The authors refer all field strengths to a radiated power of 1 kW. There are numerous v.h.f. equipments radiating only a few watts or even fractions of a watt. I would suggest that it would be more convenient if the standard radiation were 1 watt rather than 1 kW.

**Mr. R. A. Rowden:** An interesting result which the measurements have demonstrated is the fact that the median (distance) field strength is apparently independent of frequency, the effect of irregular terrain being to compensate for the expected increase of field strength with frequency over a smooth earth predicted by the theory. The authors' results also show, however, that the statistical distribution of field strength is such that a very much greater range is observed on the higher frequency than on the lower.

Engineers concerned with the planning of television broadcast services must endeavour to provide an adequate field strength to as many potential receiver locations as possible. Planning on the basis of median values is not therefore sufficient unless the statistical distribution is known and taken into account. In planning we are more concerned with something like the 90% (distance) values than with the median values. Consideration of the 90% values will show that, because of the slope of the distribution curve for the higher frequency, the independence with frequency is largely lost, and the higher we go in frequency the higher will be the median field value required to provide an adequate service.

**Mr. G. Millington:** All in industry who must use these frequencies for communications are indebted to the Department of Scientific and Industrial Research for undertaking this kind of research on their behalf. The authors have stressed the application of their curves to the determination of the service areas of television transmitters, and I should like to underline the statistical nature of the curves and their inapplicability in locations where the conditions are either especially favourable or very difficult. I doubt also whether the curves would be of much use in the specific problem of siting aerials for relay links.

I feel that there should be some criterion of the roughness of the ground to which these curves refer. Obviously there are sites where the conditions are almost ideal, while they can scarcely apply to very mountainous terrain. With regard to

Fig. 1, I presume that most of the results refer to eqn. (2), i.e. to situations for which the heights and distances are such that the receiver is beyond the interference pattern of maxima and minima; otherwise the practical field strength might well be much greater than the theoretical value if the latter refers to an interference minimum. I notice in Fig. 4(*b*) a suggested minimum in the statistical curve. Does this mean that even on a statistical basis such minima should be observed?

How are the curves calculated in the neighbourhood of the horizon where the geometric-optical formula is invalid, and how do they join the curves accepted by the C.C.I.R. for those distances well beyond the horizon at which the signal reaches the receiver mainly by tropospheric scattering?

In view of the fact that the C.C.I.R. is proposing to compute a new set of curves for 30–300 Mc/s for distances beyond the interference maxima and minima, based on a smooth earth and a standard atmosphere, I wonder whether the authors regard this as a waste of time as a result of their work.

Finally, I presume that the general reduction of field strength caused by the roughness of the ground is simply due to a redistribution of the incident energy. It is scattered in other directions, and the loss does not represent an actual increase of the energy absorbed by the earth.

**Mr. J. K. S. Jowett:** I should like to know in what season of the year these measurements were carried out; would the presence or absence of leaves on the trees modify the results?

In Section 3 of the paper by Dr. Saxton and Mr. Harden considerable use is made of median (site) and median (distance) values; we have had references in other papers to median (time) values. It seems to me that the median (site) value should indicate the median value taken from a number of sites, which is not at all the meaning intended by the authors. In the same way median (time) value means median value taken over a number of different times. I can see the authors' difficulties here, but wonder whether they are satisfied that they have made the best choice of terms.

Figs. 1(*a*) and 1(*b*) are most interesting, but do they represent the ratio between the true maximum and the true minimum, or merely the difference between the lower and upper decile values?

I should also like more information about how the field strength varies within the local sites. There are, of course, standing-wave patterns in the field strength; are we correct in assuming that no more advantage can be taken of these patterns at 600 Mc/s than at 60 Mc/s? It might be contended that the median value for a local site is the most important factor. Perhaps, however, at 600 Mc/s the near-maximum values are more important because they are so much more easily found. If this is true it may go some way to meeting Mr. Rowden's argument that values exceeded at 90% of the sites rather than median values should be adopted for the planning of broadcasting systems.

The authors state in Section 3.3 that "It may be noted that the corresponding curve for the Slough results [Fig. 1(*a*)] lies within the limits of Fig. 1(*b*), which shows that the variations in field strength occurring at a given receiving site are predominantly determined by the characteristics of the site and do not depend to any significant extent upon the height of the transmitter." I have plotted the value from Fig. 1(*a*) on to Fig. 1(*b*), and it seems that the Slough results come very close to the upper edge of the envelope shown in Fig. 1(*b*). If so (and if any comparison at all is justified), it suggests that the range of variation with the low transmitting aerial is greater and that the range of variation is, in fact, a function of transmitting height. Furthermore, if the authors were to make the comparison for a restricted range of survey, say for 56 km round Slough, and for the same distance round Sutton Coldfield, perhaps the reduction in range of variation for the higher transmitting aerial at Sutton Coldfield would show up even more markedly.

Finally, do the authors think that these results would be in any way applicable to mobile reception where the height of the receiving aerial is perhaps 2 m?

**Mr. E. C. Cork:** The general results set out in the two papers are substantially in accordance with the F.C.C. F50/50 curves published in 1952, which also show that the field strength is approximately independent of frequency. A point of importance is the resulting service area at ultra high frequencies. The Federal Communications Commission specify a minimum field strength of 74 db above 1 $\mu$V/m (db$\mu$) to give a Grade-A service at ultra high frequencies. If we assume an effective radiated power of 100 kW and a transmitting aerial height of 200 m, Fig. 3(*b*) of the paper by Dr. Saxton predicts a service range of 35 km. The F.C.C. standard for Grade-A service in band 1 is 68 db$\mu$. On this basis, from the same curve the service range of a similar transmitter at 50 Mc/s is 55 km. Thus, by shifting to ultra high frequency the service range has been reduced by about 20 km. Furthermore, Table 1 in the paper by Dr. Saxton and Mr. Harden shows a range of variation in the field strengths at a given distance from the transmitter as much as 15–20 db greater at 600 Mc/s than at 100 Mc/s. Thus, to provide a Grade-A service to 90% of the receiving sites at ultra high frequencies a figure of 84 db$\mu$ might be necessary, resulting in a reduction of service range to 21 km.

Mr. Jowett has referred to the siting of receiving aerials, and from Fig. 1(*a*) we note the local site variations can be as much as 10–15 db within 30–40 m. Thus a site survey is as necessary as a high-gain array, particularly since it is known that the u.h.f. local field distortion can greatly reduce the effective gain.

The results so far have been mainly concerned with semi-rural areas. It seems clearly necessary to extend these measurements to include radiation over towns, say from a chosen London site. The field strength should be measured on the roofs of buildings and within such structures as may be expected to use indoor aerials.

It would be useful if some tests could be made of the field distortion under typical receiving conditions, in order to throw light on the value of the proposal contained in the first Television Advisory Committee report to use cross-polarizations as means of reducing interference between stations on the same frequency. It has been suggested that good discrimination is obtainable by this means, and whilst under idealized conditions it may be as much as 20 db, some preliminary measurements indicate a much lower figure in the majority of cases. If the practical conditions of working make this advantage illusory, then on this ground alone a uniform scheme of polarization would better serve the requirements of the receiving aerial by allowing a single-aerial system to take several transmissions or wavebands, thus reducing the complexity, multiplicity, unsightliness and cost of the receiving system. Furthermore, it would permit of planning and development in relation to both transmitting and receiving aerials with reasonable confidence in the avoidance of duplication. Advantage could then be taken of American and other experience, and this would ultimately have a bearing on our ability to sell abroad.

**Mr. E. Fitch:** It has been shown by Dr. Saxton that for a given transmitted power the field strength at a point within the horizon is independent of frequency. As the frequency is raised, however, a given type of aerial becomes physically smaller, so that a more elaborate aerial must be used to maintain a constant aperture. Unfortunately, the field becomes more complex as the frequency is raised, with the result that full advantage may

not be taken of the aperture at the higher frequencies. Consequently the receiver input voltage is likely to fall as the frequency is increased.

It is tempting to place a receiving aerial so as to take advantage of a high local peak in field strength, but such a peak arises from the addition of two or more signals with a favourable phase relationship. Day-to-day variations of the refractive index of the atmosphere may alter such relationships, so causing the pattern of field strength to move. A spot with a large signal to-day may give a small one to-morrow.

The theoretical formulae for a smooth earth quoted by Dr. Saxton may be obtained by considering two rays, the direct and the reflected. The magnitude of each ray decreases inversely with the distance, but when terminal heights are small the phase relationship between them is such that they almost cancel, the resultant field decreasing inversely as the square of the distance. If the earth is no longer smooth, so that the reflected ray becomes a bundle of rays random in amplitude and phase, it seems remarkable that Dr. Saxton should find it possible to describe the phenomena by so small a modification of these formulae.

**Dr. R. L. Smith-Rose:** Dr. Saxton points out that television services are moving into higher frequency bands, and he mentioned that 470–960 Mc/s is one of these bands. It so happens that since this work was started that band has been split up into two parts, commonly known as bands IV and V, and the frequency selected for carrying out the experiments described by the authors is in the gap between the two bands.

It is work of this type and that carried out elsewhere which is gradually making us realize that at these higher frequencies we have reached a limit beyond which we cannot apply smooth curves, calculated on a theoretical basis, to practical conditions. It is only by carrying out experimental work of this sort and building up empirical curves in place of the smooth theoretical curves that we can make a realistic approach to the whole situation.

As Dr. Saxton has emphasized in this and previous papers, we have to adopt a statistical approach towards this subject. It would seem that the nomenclature for specifying signal strength will be complicated in the future, because to the conditions applying to these two papers must be added the fact that as we go further away from the transmitter, the field strength measured at any fixed point varies with time.

One of the major points that has been brought out in the paper on basic characteristics is the fact that whereas theoretically over an ideal smooth earth the field strength would vary proportionately to the frequency, this proportionality is largely removed by the reverse effect introduced by the roughness of the terrain. It is thus seen that, taking the matter very broadly, the field strength is independent of the frequency.

From the aspect of the designer and manufacturer of receivers, who prefers to think in terms of signal voltage applied to the receiver, it is clear that using a half-wavelength dipole for reception, the signal voltage will vary inversely as the frequency. This is a point, incidentally, which is brought out in the recent second report of the Television Advisory Committee, namely that for sound-broadcasting reception with a half-wavelength dipole at 90 Mc/s, for otherwise similar conditions, the signal would be one-half of what it is on the television frequency of 45 Mc/s. Extending this to 500 Mc/s, the signal voltage will be one-tenth of what it is at 50 Mc/s. From this sort of reasoning we can arrive at the same outlook as Mr. Cork; and we realize that to obtain the same signal voltage at the two frequencies we need 100 times the effective radiated power at the higher frequency.

I agree that if you are selling a broadcasting or television service, it is of little use to refer to median values. You must talk about 90% or 99% values. But there is another factor to be borne in mind. When we want to specify the freedom of the service from interference from any station working in the same channel, we require to know 1% and 10% values. It is thus likely that in the future we shall have to draw field-strength curves for 1%, 10%, 50%, 90% and 99% values to meet all requirements, and this has already been suggested at one of the study groups of the C.C.I.R.

I am also intrigued by the idea that we shall have to discuss roughness or smoothness, as the case may be, at future meetings of C.C.I.R.

**Mr. P. P. Eckersley:** The authors relate "roughness" of the ground over which the waves travel and the attenuation they suffer. If this roughness varies in the sense that successive lengths along the path of the ray have substantially different degrees of roughness, is it possible to calculate the overall attenuation over the whole path?

The attenuation of medium waves is related to ground conductivity, which may vary in very large degree over the path of a given ray. Thus the waves suffer sudden changes in attenuation at the boundaries of one type of ground and another. In the early days of broadcasting I made somewhat rash assumptions when attempting to calculate service areas in regions of variable ground conductivity; how rash, the B.B.C. has been at pains to point out in an article* published some 20 years after the assumptions were made.

Does a like problem, this time in terms of roughness rather than conductivity, arise using metric or centimetric waves, and is it possible to solve it if it does?

**Mr. H. Stanesby:** Although the matter is not covered in the papers, I am very interested in the enhancement of signal strength that often arises from diffraction when there is a high mountain ridge between a transmitter and a distant receiver, and I should like to know whether this effect is likely to depend upon the profile of the top of the ridge, i.e. whether it has a broad, rounded top or is quite sharp. I should also like to know whether in carrying out these field-strength surveys the authors came upon much evidence of substantial re-radiation from nearby objects; whether, for example, local reflections are likely to give rise to more troublesome echo effects at, say, 200 Mc/s than are experienced at frequencies of the order of 50 Mc/s.

Mr. Cork mentions the desirability of studying the variations of field strength that occur in buildings. It occurs to me that the difficulties of providing reasonable v.h.f. coverage of the country are going to be very much increased if one proceeds on the assumption that indoor receiving aerials will be used.

**Mr. A. M. Thornton:** I should like to ask the authors whether the results, as analysed and presented for the convenience mainly of the broadcasting authorities, could be re-presented in a way which would be of more value to those interested in radio links. Alternatively, have the authors any plans for continuing their work using, perhaps, higher and more directive antennae—as would normally be used in radio-link work?

* KIRKE, H. L.: "Calculations of Ground-Wave Field Strengths on a Composite Land and Sea Path," *Proceedings of the Institute of Radio Engineers*, 1949, 37, p. 489.